

Memorandum

To: U.S. Environmental Protection Agency (EPA) Region 10

From: CDM Smith Federal Programs Corporation

Date: December 17, 2018 (Revised October 9, 2019)

Subject: Benzo(a)Pyrene Non-Cancer HQs and PRGs

Introduction and Purpose

The purpose of this memorandum is to confirm that concentrations of benzo(a)pyrene (BaP) at the Portland Harbor site do not pose unacceptable non-cancer hazards, and that a BaP preliminary remediation goal (PRG) calculated based on non-cancer effects would be a higher value than the PRG based on cancer risks presented in the Explanation of Significant Differences (ESD).

In response to comments received on the proposed ESD, this memorandum has been revised to provide clarity on exposure parameters used in the BaP non-cancer calculations; to discuss the proposed reference dose (RfD) for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) that was used in the Portland Harbor Feasibility Study (FS) PRG calculations; and to confirm that the identified discrepancies in the exposure parameters between the FS and the Portland Harbor Human Health Risk Assessment (HHRA) do not impact the cancer calculations in the FS and ESD. This memorandum is organized into two sections:

- Non-Cancer Calculations
- Cancer Calculations

Non-Cancer Calculations

Two types of non-cancer calculations are presented in this memorandum – a calculation of non-cancer hazard quotients (HQs) and a calculation of PRGs based on non-cancer effects.

To confirm whether benzo(a)pyrene posed unacceptable non-cancer hazards at the Portland Harbor site, non-cancer hazards associated with the child recreational beach sediment and in-water tribal fisher direct contact in-water sediment exposure scenarios and the recreational and subsistence clam consumption exposure scenarios were evaluated. These exposure scenarios were selected because they represent greatest potential benzo(a)pyrene exposure.

In addition, PRGs based on non-cancer effects were calculated for comparison with the PRG based on cancer risks presented in the ESD. For calculation of the non-cancer sediment PRG, PRGs were calculated for beach sediment exposure scenarios for the dockside worker, transient, recreational beach user (child), high frequency fisher, and the tribal fisher, and for in-water

sediment exposure scenarios for the in-water worker, high frequency fisher, tribal fisher, diver wet suit, and diver dry suit.

Methodology

Hazard Quotient - To calculate the non-cancer BaP HQ, the chronic daily intake (CDI) was compared to the corresponding RfD in the following equation (EPA 1989):

$$HQ = CDI / RfD$$

Non-cancer Sediment PRG - To calculate the non-cancer sediment PRG for BaP, the equations presented in the Portland Harbor FS Appendix B: Derivation of Risk-Based PRGs were used. PRGs were calculated for both incidental ingestion (equation B3-1) and dermal contact (equation B3-8) with sediment and then combined to determine a PRG for sediment exposure. Separate shellfish tissue PRGs were developed based on equation B3-15 of the FS assuming human shellfish consumption rates of 3.3 g/day and 18 g/day. Human health shellfish consumption sediment PRGs were based on equation B3-23 of the FS. These equations from the FS are provided in **Attachment 1**.

Exposure Parameters

Exposure parameters used in the non-cancer calculations were initially obtained from Table B3-1 of the Portland Harbor FS - Appendix B. However, upon review of these parameters, discrepancies were noted between the exposure parameter values presented in Table B3-1 of the FS and Tables 3-21, 3-22, and 3-24 of the HHRA. The HHRA exposure values are presented in **Table 1**. The values with discrepancies when compared to the FS are highlighted in orange on the table and are summarized below:

- **Transient, beach sediment exposure** – This receptor did not have any exposure parameters listed in FS Table B3-1. However, a review of the Excel calculation file for PAHs for this receptor uncovered several formula errors for the non-cancer averaging time, the exposure frequency (50 days instead of 365 days), the exposure duration (25 years instead of 2 years), the exposed skin surface area (3,300 cm² instead of 5,700 cm²), and the adherence factor (0.2 mg/cm² instead of 0.3 mg/cm²). The exposure parameter values shown on **Table 1** match HHRA Table 3-21.
- **High Frequency Fisher, in-water sediment exposure** – FS Table B3-1 does not include a high frequency fisher as a receptor. HHRA Table 3-22 lists a sediment ingestion rate of 50 mg/day for a reasonable maximum exposure (RME) scenario and 25 mg/day for central tendency exposure (CTE) scenario for a high frequency fisher. The sediment ingestion rate of 50 mg/day for an RME scenario was used in the non-cancer calculations in this memorandum.
- **Tribal Fisher, in-water sediment exposure** - FS Table B3-1 does not distinguish between RME and CTE exposure and lists an incidental sediment ingestion rate of 100 mg/day. HHRA Table 3-22 lists a sediment ingestion rate of 50 mg/day for an RME scenario and 25 mg/day for CTE scenario for the tribal fisher for the in-water sediment exposure. The sediment ingestion rate of 50 mg/day for an RME scenario was used in the non-cancer calculations in this memorandum.

Additional discrepancies for the tribal fisher were highlighted in the previous version of **Table 1** for this memorandum. However, upon additional review, the previously indicated values from the FS were determined to match the HHRA and so the orange highlighting was removed.

Toxicity Values

According to the *Toxicological Review of Benzo(a)pyrene* (EPA, 2017b), the current RfD for BaP is 3.0×10^{-4} mg/kg-day. As shown in **Table 1**, this is the RfD value for BaP that is used for the non-cancer calculations in this memorandum. This is also the same RfD value that was used in the FS as shown in FS Table B3-2.

Non-Cancer Hazard Estimates and Conclusions

Hazard Quotient – The calculated hazard quotients are summarized in **Table 2**. The hazard quotient calculations are provided in **Attachment 2**. The results of the evaluation determined that the maximum direct contact beach and in-water sediment hazard quotients were 0.03 (at approximately RM 4.8 along the east bank of the Willamette River – Beach 04B024) and 0.06 (at River Mile 6 West), respectively, and that the maximum recreational and subsistence clam consumption exposure hazard quotients were 0.08 and 0.4, respectively, both at River Mile 6 West. These results demonstrate that unacceptable non-cancer risks associated with benzo(a)pyrene do not exist at the Portland Harbor site.

Non-cancer Sediment PRG - Non-cancer benzo(a)pyrene sediment PRGs are summarized in **Table 3**. It was determined that non-cancer benzo(a)pyrene beach sediment PRGs range from 12,470 to 536,389 µg/kg and non-cancer benzo(a)pyrene in-water sediment PRGs range from 231,731 to 10,365,812 µg/kg. These PRGs based on non-cancer effects are well above the cleanup levels in the ESD for carcinogenic PAHs based on cancer risks which are 85 µg/kg for beach sediment and 774 µg/kg for in-water sediment outside the navigation channel.

Similarly, non-cancer benzo(a)pyrene sediment PRGs for the human health clam consumption exposure scenario were also calculated and are summarized in **Table 4**. The non-cancer benzo(a)pyrene clam consumption sediment PRGs range from 208,643 µg/kg to 3,526,422 µg/kg. These PRGs based on non-cancer effects are well above the clam consumption cleanup level in the ESD for carcinogenic PAHs based on cancer risks of 1,076 µg/kg.

Cancer Calculations

Due to the discrepancies between FS Table B3-1 and HHRA Tables 3-21, 3-22, and 3-24 identified above, there is concern whether the HHRA exposure parameters were used in the PRG calculations in the FS. Instead of recalculating the cancer risk FS calculations, comparisons were made between the non-cancer calculations conducted in this memorandum and the non-cancer calculations provided in FS Table B3-4.

Comparison to FS

The non-cancer BaP PRGs in this memo were calculated using exposure values from the HHRA tables. As shown in **Table 3**, Despite the discrepancies in the exposure parameters listed above, the sediment PRGs calculated in this memo matched the values presented in FS Table B3-4, with a few exceptions. Since most of these non-cancer calculation results match, it appears that the

memo and FS calculations were conducted with the same parameter values from the HHRA. The exceptions are:

- Transient, beach sediment exposure - FS calculated HQ=756,663 while Non-Cancer BaP PRG memo calculation HQ=49,728.
- Recreational Beach user (child), beach sediment exposure – This was not calculated in the FS, so calculated PRG value is new.
- Diver in Dry Suit, in-water sediment exposure – This was not calculated in the FS, so calculated PRG value is new.

Although **Table 3** lists new values for the non-cancer BaP PRG concentrations for the Recreational Beach user (child) and the Diver in Dry Suit, the non-cancer BaP PRG concentrations are much greater than the cancer BaP PRG concentrations in the FS and ESD. Thus, the absence of a non-cancer PRG calculation in the FS for these two receptors would not change the PRG that was determined in the FS.

The difference in the non-cancer PRG value for the transient beach sediment exposure scenario calculated in the Non-Cancer BaP PRG memo compared to the FS appears to be an error in the FS calculation. As noted above, non-cancer PRG concentrations result in a much greater value than the cancer PRG concentrations. Thus, although the revised calculated non-cancer PRG value from the memo for the transient is much lower than reported in the FS, the cancer PRG concentrations would still be lower, thus this error does not change the PRG that was determined in the FS.

However, since the non-cancer BaP PRG value for the transient beach sediment exposure scenario that is presented in FS Table B3-4 appears to be incorrect, the calculated PRG values in the column for the transient receptor for all of the COCs in FS Table B3-4 were checked for accuracy. Although all the COCs listed on FS Table B3-4 were checked, arsenic and cPAHs are the only COCs for beach sediment for RAO 1 according to FS Table 2.2-4 and HHRA Table 7-1, which lists the chemicals potentially posing unacceptable risks for human health. The recalculated non-cancer based and cancer based PRG values for the transient beach sediment exposure scenario are provided in **Table 5** along with the selected risk-based PRG (based on the Tribal Fisher scenario) from FS Table B3-4. As shown in **Table 5**, the recalculated PRGs for the transient exposure scenario are higher than the selected risk-based PRG (based on the Tribal Fisher scenario), thus the risk driver remains the same as determined in the FS and the calculation errors do not change the PRG that was determined in the FS.

Comparison to ESD

The ESD is focused on the change in the oral cancer slope factor (CSF) for BaP from 7.3 to 1 milligram per kilogram per day (mg/kg-day). As such, only calculations for cancer BaP PRGs were adjusted. The cancer calculations were adjusted by reducing the BaP CSF by a factor of 7.3, thus, increasing the beach sediment PRG of 12 µg/kg to 85 µg/kg and increasing the nearshore in-water sediment PRG of 106 µg/kg to 774 µg/kg. In essence, all other exposure parameters were kept the same as used in the FS cancer calculations. So, if the FS cancer calculations are correct, then the ESD cancer calculations are correct.

Since most of the non-cancer BaP sediment PRGs calculated for this memo match the values presented in Table B3-4 of the Portland Harbor FS (Appendix B), the discrepancies in the exposure parameters appear to indicate errors in FS Table B3-4 and not necessarily errors in the FS cancer calculations for the PRG values, with the exception of the transient exposure scenario. However, as shown in the recalculation of the transient exposure scenario values in **Table 5**, the transient exposure scenario was not the risk driver. Thus, the cancer risk based PRG calculations in the FS for the risk driver scenario (tribal fisher) used exposure parameters consistent with the HHRA and the cancer calculations presented in the FS and ESD are correct.

Conclusions

Based on the evaluation presented in this memorandum, concentrations of BaP at the Portland Harbor site do not pose unacceptable non-cancer hazards. In addition, a BaP PRG calculated based on non-cancer effects would be a higher value than the PRG based on cancer risks presented in the ESD so the PRG value provided in the ESD is accurate. Also, despite the identified discrepancies in the exposure parameters in FS Table B3-4 compared to the HHRA, the BaP PRG cancer calculations for the risk driver in the FS and ESD appear to be based on exposure parameters consistent with the HHRA.

References

- EPA.2017a. *Record of Decision, Portland Harbor Superfund Site*. January 3.
- EPA. 2017b. *Toxicological Review of Benzo[a]pyrene*. Integrated Risk Information System, National Center for Environmental Assessment, Office of Research and Development. Washington, DC. January 19.
- EPA. 1989. *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)*, Interim Final. Office of Solid Waste and Emergency Response, EPA/540/1-89/002. December 1989.

List of Attachments

- Attachment 1: PRG Equations from Portland Harbor FS Appendix B
Attachment 2: BaP Non-Cancer Hazard Quotient Calculations

List of Tables

- Table 1 Summary of Exposure Parameters for PRG Calculations
Table 2 Benzo(a)Pyrene Non-Cancer Hazard Quotient Summary
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Table 5 Recalculation of PRGs for RME Transient Exposure to Beach Sediment

Table 1 - Summary of Exposure Parameters for PRG Calculations

Media	Scenario	Reference Dose (RfD)	Body Weight (BW)	Non-Cancer Averaging Time (AT)	Exposure Frequency (EF)	Exposure Duration (ED)	Sediment Ingestion Rate (IRS)	Skin Surface Area (SA)	Adherence Factor (AF)	Dermal Absorption Efficiency (ABS)	Conversion
		(mg/kg-day)	(kg)	(days)	(days/yr)	(years)	(mg/day)	(cm ²)	(mg/cm ²)	(Unitless)	(kg/ug)
Beach Sediment	Dockside Worker	3.00E-04	70	9125	50	25	200	3300	0.2	0.13	1.00E-09
Beach Sediment	Transient	3.00E-04	70	730	365	2	200	5700	0.3	0.13	1.00E-09
Beach Sediment	Recreational Beach User (child)	3.00E-04	15	2190	94	6	200	2800	3.3	0.13	1.00E-09
Beach Sediment	High Frequency Fisher	3.00E-04	70	10950	156	30	100	5700	0.3	0.13	1.00E-09
Beach Sediment	Tribal Fisher	3.00E-04	70	25550	260	70	100	5700	0.3	0.13	1.00E-09
In-Water Sediment	In-water Worker	3.00E-04	70	3650	10	10	200	3300	0.2	0.13	1.00E-09
In-Water Sediment	High Frequency Fisher	3.00E-04	70	10950	156	30	50	1980	0.3	0.13	1.00E-09
In-Water Sediment	Tribal Fisher	3.00E-04	70	25550	260	70	50	1980	0.3	0.13	1.00E-09
In-Water Sediment	Diver Wet Suit	3.00E-04	70	9125	5	25	50	18150	0.3	0.13	1.00E-09
In-Water Sediment	Diver Dry Suit	3.00E-04	70	9125	5	25	50	2510	0.3	0.13	1.00E-09

Notes:

Exposure values shown in this table are from Tables 3-21, 3-22 and 3-24 of the Portland Harbor HHRA.

Discrepancies (highlighted in orange) were noted between the exposure values presented in Table B3-1 of the Portland Harbor FS (Appendix B) and the HHRA.

Abbreviations:

cm² = square centimeters

FS = Feasibility Study

HHRA = Human Health Risk Assessment

kg = kilogram

kg/ug = kilogram per microgram

mg/cm² = milligrams per square centimeter

mg/day = milligrams per day

mg/kg-day = milligram per kilogram-day

PRG = Preliminary Remediation Goal

ug/kg = microgram per kilogram

Table 2 – Benzo(a)Pyrene Non-Cancer Hazard Quotient Summary

Exposure Scenario	Minimum HQ	Maximum HQ	Location of Maximum
Child Recreational Beach User - Beach Sediment Exposure - RME	0.0004	0.03	04B024
Tribal Fisher - In-Water Sediment Exposure - RME	0.00002	0.06	RM 6 West
Recreational Clam Consumption Exposure - RME	0.00005	0.08	RM 6 West
Subsistence Clam Consumption Exposure - RME	0.0003	0.4	RM 6 West

Notes:

HQ = hazard quotient

RME = reasonable maximum exposure

RM = river mile

Table 3 - Summary of Non-Cancer PRG Calculations and Comparison to PRGs in FS Table B3-4

Media	Scenario	FS Table B3-4 Non-Cancer PRG	Non-Cancer PRG (sediment)	Non-Cancer PRG (ingestion)	Non-Cancer PRG (dermal)
		(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Beach Sediment	Dockside Worker	536,389	536,389	766,500	1,786,713
Beach Sediment	Transient	756,663	49,728	105,000	94,467
Beach Sediment	Recreational Beach User (child)	NA	12,470	87,367	14,547
Beach Sediment	High Frequency Fisher	152,450	152,450	491,346	221,028
Beach Sediment	Tribal Fisher	91,470	91,470	294,808	132,617
In-Water Sediment	In-water Worker	2,681,945	2,681,945	3,832,500	8,933,566
In-Water Sediment	High Frequency Fisher	386,218	386,218	982,692	636,294
In-Water Sediment	Tribal Fisher	231,731	231,731	589,615	381,776
In-Water Sediment	Diver Wet Suit	2,022,828	2,022,828	30,660,000	2,165,713
In-Water Sediment	Diver Dry Suit	NA	10,365,812	30,660,000	15,660,435

Notes:

Non-cancer sediment PRGs were developed based on equations B3-1, B3-8 and B3-14 of the Portland Harbor FS (Appendix B). Using HHRA exposure values (Table 1) results in sediment PRGs that match the PRG values presented in Table B3-4 of the Portland Harbor FS (Appendix B) with the exception of the discrepancies highlighted in orange for the transient and recreational child beach user beach sediment exposure scenario and the in-water sediment diver dry suit.

Abbreviations:

FS = Feasibility Study

PRG = Preliminary Remediation Goal

ug/kg = microgram per kilogram

Table 4 – Benzo(a)Pyrene Non-Cancer PRG Summary

RAO 1 – Direct Contact with Sediment			Beach Sediment (Direct Contact)					In-water Sediment (Direct Contact)				
COC	Target Risk Level	Units	Dockside Worker	Transient	Recreational Beach User HQ=child	High Frequency Fisher	Tribal Fisher	In-water Worker	High Frequency Fisher	Tribal Fisher	Diver Wet Suit	Diver Dry Suit
Benzo(a)pyrene	HQ=1	µg/kg	536,389	49,728	12,470	152,450	91,470	2,681,945	386,218	231,731	2,022,828	10,365,812
RAO 2 –Shellfish Consumption			Shellfish Consumption (Tissue)		Shellfish Consumption (Sediment)		Shellfish Consumption (Tissue)		Shellfish Consumption (Sediment)			
COC	Target Risk Level	Units	3.3 g/day	3.3 g/day Infant	3.3 g/day	3.3 g/day Infant	18 g/day	18 g/day Infant	18 g/day	18 g/day Infant		
Benzo(a)pyrene	HQ=1	µg/kg	6,636	NA	3,526,422	NA	1,217	NA	208,643	NA		

Table 5 - Recalculation of PRGs for RME Transient Exposure to Beach Sediment

Media/Scenario	Chemical of Concern (COC)	FS Table B3-4			Recalculated					
		Risk-based PRG for Tribal Fisher	Cancer PRG (10 ⁻⁶ target risk)	Non-Cancer PRG (Target HQ=1)	Cancer (10 ⁻⁶ target risk)			Non-Cancer (Target HQ=1)		
					PRG (sediment)	PRG (ingestion)	PRG (dermal)	PRG (sediment)	PRG (ingestion)	PRG (dermal)
					(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Beach Sediment - Transient	Arsenic	400	6,983	1,122,000	6,500	8,167	31,839	83,565	105,000	409,357
	Aldrin	21	460	83,862	388	721	843	5,660	10,500	12,281
	Chlordanes	1,667	28,547	1,784,218	26,080	35,000	102,339	130,402	175,000	511,696
	DDx	1,910	30,807	1,870,425	28,674	36,029	140,466	139,276	175,000	682,261
	Dieldrin	23	489	139,770	413	766	895	9,434	17,500	20,468
	Dioxins/Furans (2,3,7,8-TCDD eq)	0.005	0.08	2.6	0.07	0.09	0.37	0.19	0.25	0.96
	Bis-2-Ethylhexylphthalate	25,901	559,081	55,908,096	471,698	875,000	1,023,392	3,773,585	7,000,000	8,187,135
	Hexachlorobenzene	227	4,892	2,236,324	4,127	7,656	8,955	150,943	280,000	327,485
	PCBs	145	3,420	48,853	2,788	6,125	5,117	3,186	7,000	5,848
	cPAHs	12	967*	756,663	5,802	12,250	11,021	49,728	105,000	94,467
	PBDEs	NA	NA	NA	NA	NA	NA	15,931	35,000	29,240

Notes:

Exposure parameters for the transient receptor are from Table 3-21 of the Portland Harbor HHRA.

Chemical-specific values are from Table B3-2 of the Portland Harbor FS.

Discrepancies (highlighted in orange) were noted between the recalculated PRGs and the PRGs presented in Table B3-4 of the Portland Harbor FS (Appendix B).

* This value was calculated using the old cancer slope factor for cPAHs.

Abbreviations:

cm² = square centimeters

FS = Feasibility Study

HHRA = Human Health Risk Assessment

HQ = hazard quotient

kg = kilogram

kg/ug = kilogram per microgram

mg/cm² = milligrams per square centimeter

mg/day = milligrams per day

mg/kg-day = milligram per kilogram-day

PRG = Preliminary Remediation Goal

RME = reasonable maximum exposure

ug/kg = microgram per kilogram

Table 5 - Recalculation of PRGs for RME Transient Exposure to Beach Sediment

Media/Scenario	Chemical of Concern (COC)	Chemical -Specific Values			RME Exposure Parameters for Transient Receptor								
		Slope Factor (SF)	Reference Dose (RfD)	Dermal Absorption Efficiency (ABS)	Body Weight (BW)	Non-Cancer Averaging Time (AT _{NC})	Cancer Averaging Time (AT _C)	Exposure Frequency (EF)	Exposure Duration (ED)	Sediment Ingestion Rate (IRS)	Skin Surface Area (SA)	Adherence Factor (AF)	Conversion
		(mg/kg-day) ⁻¹	(mg/kg-day)	(Unitless)	(kg)	(days)	(days)	(days/yr)	(years)	(mg/day)	(cm ²)	(mg/cm ²)	(kg/ug)
Beach Sediment - Transient	Arsenic	1.50E+00	3.00E-04	0.03	70	730	25,550	365	2	200	5700	0.3	1.00E-09
	Aldrin	1.70E+01	3.00E-05	0.1	70	730	25,550	365	2	200	5700	0.3	1.00E-09
	Chlordanes	3.50E-01	5.00E-04	0.04	70	730	25,550	365	2	200	5700	0.3	1.00E-09
	DDx	3.40E-01	5.00E-04	0.03	70	730	25,550	365	2	200	5700	0.3	1.00E-09
	Dieldrin	1.60E+01	5.00E-05	0.1	70	730	25,550	365	2	200	5700	0.3	1.00E-09
	Dioxins/Furans (2,3,7,8-TCDD eq)	1.30E+05	7.00E-10	0.03	70	730	25,550	365	2	200	5700	0.3	1.00E-09
	Bis-2-Ethylhexylphthalate	1.40E-02	2.00E-02	0.1	70	730	25,550	365	2	200	5700	0.3	1.00E-09
	Hexachlorobenzene	1.60E+00	8.00E-04	0.1	70	730	25,550	365	2	200	5700	0.3	1.00E-09
	PCBs	2.00E+00	2.00E-05	0.14	70	730	25,550	365	2	200	5700	0.3	1.00E-09
	cPAHs	1.00E+00	3.00E-04	0.13	70	730	25,550	365	2	200	5700	0.3	1.00E-09
	PBDEs	NA	1.00E-04	0.14	70	730	25,550	365	2	200	5700	0.3	1.00E-09

Notes:

Exposure parameters for the transient receptor are from Table 3-21 of the Portland Harbor HHRA.

Chemical-specific values are from Table B3-2 of the Portland Harbor FS.

Discrepancies (highlighted in orange) were noted between the recalculated PRGs and the PRGs presented in Table B3-4

Portland Harbor FS (Appendix B).

* This value was calculated using the old cancer slope factor for cPAHs.

Abbreviations:

cm² = square centimeters

FS = Feasibility Study

HHRA = Human Health Risk Assessment

HQ = hazard quotient

kg = kilogram

kg/ug = kilogram per microgram

mg/cm² = milligrams per square centimeter

mg/day = milligrams per day

mg/kg-day = milligram per kilogram-day

PRG = Preliminary Remediation Goal

RME = reasonable maximum exposure

ug/kg = microgram per kilogram

Attachment 1

PRG Equations from Portland Harbor FS Appendix B

B3.0 HUMAN HEALTH RISK-BASED PRGS

This section presents the calculation of human health risk-based preliminary remediation goals (PRGs) in sediment and biota. Risk-based PRGs were calculated for all contaminants that posed an excess lifetime cancer risk greater than 1×10^{-6} or a hazard quotient greater than 1 in the final Portland Harbor Baseline Human Health Risk Assessment (BHHRA, Kennedy/Jenks 2013) assuming reasonable maximum exposure. For cancer effects, risk-based PRGs were calculated as the concentration consistent with a specified target excess cancer risk (TR) of 1×10^{-6} . For non-cancer effects, the risk-based PRGs were the calculated concentration that would result in a specified target hazard quotient (THQ) of 1. For both cancer and noncancer effects, the PRGs are calculated based on specified exposure pathways and receptors. Exposure values are summarized in **Table B3-1**, and unless otherwise noted, the source for each value is provided in Tables 3-21 through 3-25 in the BHHRA. A summary of the human health risk-based PRGs is presented in **Tables B3-4** and **B3-5**.

B3.1 PRGS FOR DIRECT CONTACT WITH SEDIMENT

Risk-based PRGs based on direct-contact pathways with sediment are calculated to account for incidental ingestion and dermal exposures. These values are then combined to derive a single risk-based PRG protective of both exposure pathways. These PRGs are presented in **Table B3-4** and the lowest value for each contaminant was selected as the risk-based PRG for RAO 1.

B3.1.1 Incidental Ingestion of Sediment

Risk-based PRGs associated with the incidental ingestion of sediment were calculated for child or adult receptors as appropriate using the following equations adapted from Section 3.5.1 of the BHHRA:

Noncancer effects:

$$PRG_{sed} = \frac{THQ \times BW \times AT_{nc}}{EF \times ED \times \frac{1}{RfD} \times IRS \times 10^{-6} \text{ kg / mg}} \quad \text{Equation B3-1}$$

Carcinogenic effects:

$$PRG_{sed} = \frac{TR \times BW \times AT_c}{EF \times ED \times CSF \times IRS \times 10^{-6} \text{ kg / mg}} \quad \text{Equation B3-2}$$

When exposure was assumed to occur from childhood through adult years, risk-based PRGs based on carcinogenic effects were age-weighted using the following Equation B3-4:

$$PRG_{sed} = \frac{TR \times AT_c}{CSF \times EF \times IFS_{adj} \times 10^{-6} \text{ kg / mg}} \quad \text{Equation B3-4}$$

where:

$$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a} \quad \text{Equation B3-5}$$

and:

- PRG_{sed} = risk-based PRG in soil or sediment (µg/kg or mg/kg)
- IFS_{adj} = age-adjusted soil/sediment incidental ingestion factor [(mg-year)/(kg-day)]
- IRS_a = incidental sediment ingestion rate-adults (mg/day)
- IRS_c = incidental sediment ingestion rate-children (mg/day)
- EF = exposure frequency (days/year)
- ED_a = exposure duration – adult (years)
- ED_c = exposure duration – child (years)
- BW_a = body weight – adult (kg)
- BW_c = body weight – child (kg)
- AT_{nc} = averaging time, noncancer (days)
- AT_c = averaging time, cancer (days)
- THQ = target hazard quotient
- TR = target cancer risk
- CSF = cancer slope factor (mg/kg-day)⁻¹

Risk-based PRGs in sediment for contaminants known to be mutagenic (cPAHs) incorporate the age-dependent adjustment factors (ADAFs) of 10 and 3, respectively, for exposures occurring before 2 years of age and from ages 2 through 16 (see section 3.5.7 of the BHHRA) were calculated using Equation B3-6:

$$PRG_{sed} = \frac{TR \times AT_c}{EF \times CSF \times ISIFM_{adj} \times 10^{-6} \text{ kg / mg}} \quad \text{Equation B3-6}$$

where:

$$ISIFM_{adj} = \left(\frac{(ED_{0-2} \times IRS_c) \times 10}{BW_c} + \frac{(ED_{2-6} \times IRS_c) \times 3}{BW_c} + \frac{(ED_{6-16} \times IRS_a) \times 3}{BW_a} + \frac{(ED_{16-30} \times IRS_a) \times 1}{BW_a} \right) \quad \text{Equation B3-7}$$

and:

PRG_{sed}	= chemical concentration in soil or sediment (mg/kg)
IRS_a	= adult soil/sediment ingestion rate (mg/day)
IRS_c	= child soil/sediment ingestion rate (mg/day)
$ISIFM_{adj}$	= incidental sediment ingestion factor for mutagens (mg-yr/kg-day)
EF	= exposure frequency (days/year)
ED_{0-2}	= exposure duration ages 0-2 (years)
ED_{2-6}	= exposure duration ages 2-6 (years)
ED_{6-16}	= exposure duration ages 6-16 (years)
ED_{16-30}	= exposure duration ages 16-30 (years)
BW_a	= adult body weight (kg)
BW_c	= child body weight (kg)
AT_c	= averaging time, carcinogens (days)
CSF	= cancer slope factor (mg/kg-day) ⁻¹
TR	= target cancer risk

The exposure assumptions are provided in **Table B3-1**.

B3.1.2 Dermal Contact with Sediment

Risk-based PRGs for dermal contact with sediment were calculated for child or adult receptors as appropriate using the Equations B3-8 and B3-9 adapted from Section 3.5.2 of the BHHRA:

Non-cancer effects:

$$PRG_{sed} = \frac{THQ \times AT_{nc} \times BW}{EF \times ED \times \frac{1}{RfD} \times SA \times AF \times ABS \times 10^{-6} \text{ kg / mg}} \quad \text{Equation B3-8}$$

Cancer effects:

$$PRG_{sed} = \frac{TR \times AT_c \times BW}{EF \times ED \times CSF \times SA \times AF \times ABS \times 10^{-6} \text{ kg / mg}} \quad \text{Equation B3-9}$$

Combined child and adult age-weighted exposures resulting from dermal contact with contaminants in sediment for the recreational beach user exposure scenarios were calculated consistent with Equation B3-10:

$$PRG_{sed} = \frac{TR \times AT_c}{CSF \times EF \times DFS_{adj} \times 10^{-6} \text{ kg / mg}} \quad \text{Equation B3-10}$$

where:

$$DFS_{adj} = \frac{ED_c \times EF_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times EF_a \times AF_a \times SA_a}{BW_a} \quad \text{Equation B3-11}$$

Attachment 2

BaP Non-Cancer Hazard Quotient Calculations

Child Recreational Beach User - Beach Sediment Exposure - RME										
Location	COC	EPC	Units	Dermal		Dermal		Dermal		Total HQ
				RfD	Oral RfD	CDI	Oral CDI	HQ	Oral HQ	
03B031	Benzo(a)pyrene	5.30E+01	ug/kg	3.00E-04	3.00E-04	1.09E-06	1.82E-07	3.64E-03	6.07E-04	4.25E-03
03B033	Benzo(a)pyrene	5.20E+00	ug/kg	3.00E-04	3.00E-04	1.07E-07	1.79E-08	3.57E-04	5.95E-05	4.17E-04
04B023	Benzo(a)pyrene	4.20E+01	ug/kg	3.00E-04	3.00E-04	8.66E-07	1.44E-07	2.89E-03	4.81E-04	3.37E-03
04B024	Benzo(a)pyrene	3.60E+02	ug/kg	3.00E-04	3.00E-04	7.42E-06	1.24E-06	2.47E-02	4.12E-03	2.89E-02
05B018	Benzo(a)pyrene	8.60E+01	ug/kg	3.00E-04	3.00E-04	1.77E-06	2.95E-07	5.91E-03	9.84E-04	6.90E-03
06B022	Benzo(a)pyrene	4.40E+00	ug/kg	3.00E-04	3.00E-04	9.07E-08	1.51E-08	3.02E-04	5.04E-05	3.53E-04
06B026	Benzo(a)pyrene	6.40E+00	ug/kg	3.00E-04	3.00E-04	1.32E-07	2.20E-08	4.40E-04	7.33E-05	5.13E-04
06B030	Benzo(a)pyrene	6.60E+01	ug/kg	3.00E-04	3.00E-04	1.36E-06	2.27E-07	4.54E-03	7.55E-04	5.29E-03
09B024	Benzo(a)pyrene	1.40E+01	ug/kg	3.00E-04	3.00E-04	2.89E-07	4.81E-08	9.62E-04	1.60E-04	1.12E-03
09B026	NA	--	--	--	--	--	--	--	--	--
09B027	Benzo(a)pyrene	9.00E+00	ug/kg	3.00E-04	3.00E-04	1.86E-07	3.09E-08	6.19E-04	1.03E-04	7.22E-04
09B028	Benzo(a)pyrene	4.60E+00	ug/kg	3.00E-04	3.00E-04	9.49E-08	1.58E-08	3.16E-04	5.27E-05	3.69E-04
B001	Benzo(a)pyrene	1.40E+01	ug/kg	3.00E-04	3.00E-04	2.89E-07	4.81E-08	9.62E-04	1.60E-04	1.12E-03
B003	Benzo(a)pyrene	3.60E+02	ug/kg	3.00E-04	3.00E-04	7.42E-06	1.24E-06	2.47E-02	4.12E-03	2.89E-02
B005	Benzo(a)pyrene	1.50E+02	ug/kg	3.00E-04	3.00E-04	3.09E-06	5.15E-07	1.03E-02	1.72E-03	1.20E-02
Minimum										3.53E-04
Maximum										2.89E-02
Location of Maximum: 04B024										

Tribal Fisher - In-Water Sediment Exposure - RME																	
Location	COC	EPC	Units	Dermal		Dermal		Dermal		Dermal		Dermal		Dermal		Dermal	
				CSF	Oral CSF	LADI	Oral LADI	Risk	Oral Risk	Total Risk	RfD	Oral RfD	CDI	Oral CDI	HQ	Oral HQ	Total HQ
RM 1 West	Benzo(a)pyrene	2.40E+02	ug/kg	1.00E+00	1.00E+00	4.70E-08	3.10E-08	4.70E-08	3.10E-08	7.80E-08	3.00E-04	3.00E-04	4.70E-08	3.10E-08	1.57E-04	1.03E-04	2.60E-04
RM 1 East	Benzo(a)pyrene	8.10E+01	ug/kg	1.00E+00	1.00E+00	1.60E-08	1.00E-08	1.60E-08	1.00E-08	2.60E-08	3.00E-04	3.00E-04	1.60E-08	1.00E-08	5.33E-05	3.33E-05	8.67E-05
RM 1.5 West	Benzo(a)pyrene	4.80E+01	ug/kg	1.00E+00	1.00E+00	9.40E-09	6.10E-09	9.40E-09	6.10E-09	1.55E-08	3.00E-04	3.00E-04	9.40E-09	6.10E-09	3.13E-05	2.03E-05	5.17E-05
RM 1.5 East	Benzo(a)pyrene	1.40E+03	ug/kg	1.00E+00	1.00E+00	2.80E-07	1.80E-07	2.80E-07	1.80E-07	4.60E-07	3.00E-04	3.00E-04	2.80E-07	1.80E-07	9.33E-04	6.00E-04	1.53E-03
RM 2 West	Benzo(a)pyrene	9.80E+01	ug/kg	1.00E+00	1.00E+00	1.90E-08	1.30E-08	1.90E-08	1.30E-08	3.20E-08	3.00E-04	3.00E-04	1.90E-08	1.30E-08	6.33E-05	4.33E-05	1.07E-04
RM 2 East	Benzo(a)pyrene	1.20E+02	ug/kg	1.00E+00	1.00E+00	2.40E-08	1.50E-08	2.40E-08	1.50E-08	3.90E-08	3.00E-04	3.00E-04	2.40E-08	1.50E-08	8.00E-05	5.00E-05	1.30E-04
RM 2.5 West	Benzo(a)pyrene	1.20E+02	ug/kg	1.00E+00	1.00E+00	2.40E-08	1.50E-08	2.40E-08	1.50E-08	3.90E-08	3.00E-04	3.00E-04	2.40E-08	1.50E-08	8.00E-05	5.00E-05	1.30E-04
RM 2.5 East	Benzo(a)pyrene	4.50E+03	ug/kg	1.00E+00	1.00E+00	8.90E-07	5.80E-07	8.90E-07	5.80E-07	1.47E-06	3.00E-04	3.00E-04	8.90E-07	5.80E-07	2.97E-03	1.93E-03	4.90E-03
RM 2.5 MC	Benzo(a)pyrene	4.90E+02	ug/kg	1.00E+00	1.00E+00	9.60E-08	6.20E-08	9.60E-08	6.20E-08	1.58E-07	3.00E-04	3.00E-04	9.60E-08	6.20E-08	3.20E-04	2.07E-04	5.27E-04
RM 3 West	Benzo(a)pyrene	7.10E+02	ug/kg	1.00E+00	1.00E+00	1.40E-07	9.00E-08	1.40E-07	9.00E-08	2.30E-07	3.00E-04	3.00E-04	1.40E-07	9.00E-08	4.67E-04	3.00E-04	7.67E-04
RM 3 East	Benzo(a)pyrene	1.40E+02	ug/kg	1.00E+00	1.00E+00	2.70E-08	1.70E-08	2.70E-08	1.70E-08	4.40E-08	3.00E-04	3.00E-04	2.70E-08	1.70E-08	9.00E-05	5.67E-05	1.47E-04
RM 3.5 West	Benzo(a)pyrene	2.60E+03	ug/kg	1.00E+00	1.00E+00	5.00E-07	3.20E-07	5.00E-07	3.20E-07	8.20E-07	3.00E-04	3.00E-04	5.00E-07	3.20E-07	1.67E-03	1.07E-03	2.73E-03
RM 3.5 East	Benzo(a)pyrene	8.70E+02	ug/kg	1.00E+00	1.00E+00	1.70E-07	1.10E-07	1.70E-07	1.10E-07	2.80E-07	3.00E-04	3.00E-04	1.70E-07	1.10E-07	5.67E-04	3.67E-04	9.33E-04
RM 4 West	Benzo(a)pyrene	5.80E+02	ug/kg	1.00E+00	1.00E+00	1.10E-07	7.40E-08	1.10E-07	7.40E-08	1.84E-07	3.00E-04	3.00E-04	1.10E-07	7.40E-08	3.67E-04	2.47E-04	6.13E-04
RM 4 East	Benzo(a)pyrene	2.20E+03	ug/kg	1.00E+00	1.00E+00	4.40E-07	2.80E-07	4.40E-07	2.80E-07	7.20E-07	3.00E-04	3.00E-04	4.40E-07	2.80E-07	1.47E-03	9.33E-04	2.40E-03
RM 4.5 West	Benzo(a)pyrene	2.20E+03	ug/kg	1.00E+00	1.00E+00	4.20E-07	2.70E-07	4.20E-07	2.70E-07	6.90E-07	3.00E-04	3.00E-04	4.20E-07	2.70E-07	1.40E-03	9.00E-04	2.30E-03
RM 4.5 East	Benzo(a)pyrene	8.70E+03	ug/kg	1.00E+00	1.00E+00	1.70E-06	1.10E-06	1.70E-06	1.10E-06	2.80E-06	3.00E-04	3.00E-04	1.70E-06	1.10E-06	5.67E-03	3.67E-03	9.33E-03
RM 5 West	Benzo(a)pyrene	4.50E+03	ug/kg	1.00E+00	1.00E+00	8.80E-07	5.70E-07	8.80E-07	5.70E-07	1.45E-06	3.00E-04	3.00E-04	8.80E-07	5.70E-07	2.93E-03	1.90E-03	4.83E-03
RM 5 East	Benzo(a)pyrene	4.70E+02	ug/kg	1.00E+00	1.00E+00	9.30E-08	6.00E-08	9.30E-08	6.00E-08	1.53E-07	3.00E-04	3.00E-04	9.30E-08	6.00E-08	3.10E-04	2.00E-04	5.10E-04
RM 5.5 West	Benzo(a)pyrene	4.30E+03	ug/kg	1.00E+00	1.00E+00	8.50E-07	5.50E-07	8.50E-07	5.50E-07	1.40E-06	3.00E-04	3.00E-04	8.50E-07	5.50E-07	2.83E-03	1.83E-03	4.67E-03
RM 5.5 East	Benzo(a)pyrene	7.00E+02	ug/kg	1.00E+00	1.00E+00	1.40E-07	8.90E-08	1.40E-07	8.90E-08	2.29E-07	3.00E-04	3.00E-04	1.40E-07	8.90E-08	4.67E-04	2.97E-04	7.63E-04
RM 6 West	Benzo(a)pyrene	5.80E+04	ug/kg	1.00E+00	1.00E+00	1.10E-05	7.30E-06	1.10E-05	7.30E-06	1.83E-05	3.00E-04	3.00E-04	1.10E-05	7.30E-06	3.67E-02	2.43E-02	6.10E-02
RM 6 East	Benzo(a)pyrene	1.90E+03	ug/kg	1.00E+00	1.00E+00	3.80E-07	2.50E-07	3.80E-07	2.50E-07	6.30E-07	3.00E-04	3.00E-04	3.80E-07	2.50E-07	1.27E-03	8.33E-04	2.10E-03
RM 6.5 West	Benzo(a)pyrene	1.20E+03	ug/kg	1.00E+00	1.00E+00	2.40E-07	1.60E-07	2.40E-07	1.60E-07	4.00E-07	3.00E-04	3.00E-04	2.40E-07	1.60E-07	8.00E-04	5.33E-04	1.33E-03
RM 6.5 East	Benzo(a)pyrene	1.50E+02	ug/kg	1.00E+00	1.00E+00	2.90E-08	1.90E-08	2.90E-08	1.90E-08	4.80E-08	3.00E-04	3.00E-04	2.90E-08	1.90E-08	9.67E-05	6.33E-05	1.60E-04
RM 7 West	Benzo(a)pyrene	1.70E+03	ug/kg	1.00E+00	1.00E+00	3.30E-07	2.20E-07	3.30E-07	2.20E-07	5.50E-07	3.00E-04	3.00E-04	3.30E-07	2.20E-07	1.10E-03	7.33E-04	1.83E-03
RM 7 East	Benzo(a)pyrene	5.80E+02	ug/kg	1.00E+00	1.00E+00	1.10E-07	7.40E-08	1.10E-07	7.40E-08	1.84E-07	3.00E-04	3.00E-04	1.10E-07	7.40E-08	3.67E-04	2.47E-04	6.13E-04
RM 7.5 West	Benzo(a)pyrene	3.40E+02	ug/kg	1.00E+00	1.00E+00	6.70E-08	4.40E-08	6.70E-08	4.40E-08	1.11E-07	3.00E-04	3.00E-04	6.70E-08	4.40E-08	2.23E-04	1.47E-04	3.70E-04
RM 7.5 East	Benzo(a)pyrene	3.50E+01	ug/kg	1.00E+00	1.00E+00	6.90E-09	4.50E-09	6.90E-09	4.50E-09	1.14E-08	3.00E-04	3.00E-04	6.90E-09	4.50E-09	2.30E-05	1.50E-05	3.80E-05
RM 8 West	Benzo(a)pyrene	4.90E+02	ug/kg	1.00E+00	1.00E+00	9.60E-08	6.20E-08	9.60E-08	6.20E-08	1.58E-07	3.00E-04	3.00E-04	9.60E-08	6.20E-08	3.20E-04	2.07E-04	5.27E-04
RM 8 East	Benzo(a)pyrene	5.30E+02	ug/kg	1.00E+00	1.00E+00	1.00E-07	6.70E-08	1.00E-07	6.70E-08	1.67E-07	3.00E-04	3.00E-04	1.00E-07	6.70E-08	3.33E-04	2.23E-04	5.57E-04
RM 8 SIL	Benzo(a)pyrene	3.60E+02	ug/kg	1.00E+00	1.00E+00	7.10E-08	4.60E-08	7.10E-08	4.60E-08	1.17E-07	3.00E-04	3.00E-04	7.10E-08	4.60E-08	2.37E-04	1.53E-04	3.90E-04
RM 8.5 West	Benzo(a)pyrene	2.20E+02	ug/kg	1.00E+00	1.00E+00	4.40E-08	2.80E-08	4.40E-08	2.80E-08	7.20E-08	3.00E-04	3.00E-04	4.40E-08	2.80E-08	1.47E-04	9.33E-05	2.40E-04
RM 8.5 East	Benzo(a)pyrene	1.00E+02	ug/kg	1.00E+00	1.00E+00	2.00E-08	1.30E-08	2.00E-08	1.30E-08	3.30E-08	3.00E-04	3.00E-04	2.00E-08	1.30E-08	6.67E-05	4.33E-05	1.10E-04
RM 9 West	Benzo(a)pyrene	1.00E+02	ug/kg	1.00E+00	1.00E+00	2.00E-08	1.30E-08	2.00E-08	1.30E-08	3.30E-08	3.00E-04	3.00E-04	2.00E-08	1.30E-08	6.67E-05	4.33E-05	1.10E-04
RM 9 East	Benzo(a)pyrene	1.70E+01	ug/kg	1.00E+00	1.00E+00	3.40E-09	2.20E-09	3.40E-09	2.20E-09	5.60E-09	3.00E-04	3.00E-04	3.40E-09	2.20E-09	1.13E-05	7.33E-06	1.87E-05
RM 9.5 West	Benzo(a)pyrene	3.60E+02	ug/kg	1.00E+00	1.00E+00	7.10E-08	4.60E-08	7.10E-08	4.60E-08	1.17E-07	3.00E-04	3.00E-04	7.10E-08	4.60E-08	2.37E-04	1.53E-04	3.90E-04
RM 9.5 East	Benzo(a)pyrene	3.40E+01	ug/kg	1.00E+00	1.00E+00	6.80E-09	4.40E-09	6.80E-09	4.40E-09	1.12E-08	3.00E-04	3.00E-04	6.80E-09	4.40E-09	2.27E-05	1.47E-05	3.73E-05
RM 10 West	Benzo(a)pyrene	3.40E+02	ug/kg	1.00E+00	1.00E+00	6.70E-08	4.30E-08	6.70E-08	4.30E-08	1.10E-07	3.00E-04	3.00E-04	6.70E-08	4.30E-08	2.23E-04	1.43E-04	3.67E-04
RM 10 East	Benzo(a)pyrene	3.50E+02	ug/kg	1.00E+00	1.00E+00	6.90E-08	4.50E-08	6.90E-08	4.50E-08	1.14E-07	3.00E-04	3.00E-04	6.90E-08	4.50E-08	2.30E-04	1.50E-04	3.80E-04
RM 10.5 West	Benzo(a)pyrene	4.80E+01	ug/kg	1.00E+00	1.00E+00	9.40E-09	6.10E-09	9.40E-09	6.10E-09	1.55E-08	3.00E-04	3.00E-04	9.40E-09	6.10E-09	3.13E-05	2.03E-05	5.17E-05
RM 10.5 East	Benzo(a)pyrene	7.10E+01	ug/kg	1.00E+00	1.00E+00	1.40E-08	9.00E-09	1.40E-08	9.00E-09	2.30E-08	3.00E-04	3.00E-04	1.40E-08	9.00E-09	4.67E-05	3.00E-05	7.67E-05
RM 11 West	Benzo(a)pyrene	2.20E+02	ug/kg	1.00E+00	1.00E+00	4.30E-08	2.80E-08	4.30E-08	2.80E-08	7.10E-08	3.00E-04	3.00E-04	4.30E-08	2.80E-08	1.43E-04	9.33E-05	2.37E-04
RM 11 East	Benzo(a)pyrene	1.20E+02	ug/kg	1.00E+00	1.00E+00	2.40E-08	1.50E-08	2.40E-08	1.50E-08	3.90E-08	3.00E-04	3.00E-04	2.40E-08	1.50E-08	8.00E-05	5.00E-05	1.30E-04

Tribal Fisher - In-Water Sediment Exposure - RME (continued)																	
Location	COC	EPC	Units	Dermal		Dermal		Dermal		Total Risk	Dermal	Oral RfD	Dermal	Oral CDI	Dermal	Oral HQ	Total HQ
				CSF	Oral CSF	LADI	Oral LADI	Risk	Oral Risk		RfD		CDI		HQ		
RM 11.5 West	Benzo(a)pyrene	1.80E+01	ug/kg	1.00E+00	1.00E+00	3.50E-09	2.30E-09	3.50E-09	2.30E-09	5.80E-09	3.00E-04	3.00E-04	3.50E-09	2.30E-09	1.17E-05	7.67E-06	1.93E-05
RM 11.5 East	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RM 12 West	Benzo(a)pyrene	1.80E+03	ug/kg	1.00E+00	1.00E+00	3.50E-07	2.30E-07	3.50E-07	2.30E-07	5.80E-07	3.00E-04	3.00E-04	3.50E-07	2.30E-07	1.17E-03	7.67E-04	1.93E-03
RM 12 East	Benzo(a)pyrene	1.90E+01	ug/kg	1.00E+00	1.00E+00	3.70E-09	2.40E-09	3.70E-09	2.40E-09	6.10E-09	3.00E-04	3.00E-04	3.70E-09	2.40E-09	1.23E-05	8.00E-06	2.03E-05
Study Area Wide	Benzo(a)pyrene	3.70E+03	ug/kg	1.00E+00	1.00E+00	7.30E-07	4.80E-07	7.30E-07	4.80E-07	1.21E-06	3.00E-04	3.00E-04	7.30E-07	4.80E-07	2.43E-03	1.60E-03	4.03E-03
Minimum																	1.87E-05
Maximum																	6.10E-02
Location of Maximum:	RM 6 West																

Recreational and Subsistence Clam Consumption Exposure - RME													
Location	COC	EPC	Units	CSF	LADI	Risk (18 g/day)	LADI	Risk (3.3 g/day)	RfD	CDI (18 g/day)	HQ (18 g/day)	CDI (3.3 g/day)	HQ (3.3 g/day)
RM 1 East (UD)	Benzo(a)pyrene	8.80E-01	ug/kg	1.00E+00	9.70E-08	9.70E-08	1.80E-08	1.80E-08	3.00E-04	2.30E-07	7.67E-04	4.10E-08	1.37E-04
RM 2 East (UD)	NA	--	--	--	--	--	--	--	--	--	--	--	--
RM 2 West (UD)	Benzo(a)pyrene	1.30E+01	ug/kg	1.00E+00	1.40E-06	1.40E-06	2.60E-07	2.60E-07	3.00E-04	3.30E-06	1.10E-02	6.10E-07	2.03E-03
RM 3 East (UD)	Benzo(a)pyrene	1.60E+01	ug/kg	1.00E+00	1.80E-06	1.80E-06	3.20E-07	3.20E-07	3.00E-04	4.10E-06	1.37E-02	7.50E-07	2.50E-03
RM 3 West (UD)	Benzo(a)pyrene	1.50E+00	ug/kg	1.00E+00	1.70E-07	1.70E-07	3.00E-08	3.00E-08	3.00E-04	3.90E-07	1.30E-03	7.10E-08	2.37E-04
RM 4 East (UD)	Benzo(a)pyrene	9.80E+00	ug/kg	1.00E+00	1.10E-06	1.10E-06	2.00E-07	2.00E-07	3.00E-04	2.50E-06	8.33E-03	4.60E-07	1.53E-03
RM 4 West (UD)	Benzo(a)pyrene	3.90E+01	ug/kg	1.00E+00	4.30E-06	4.30E-06	7.90E-07	7.90E-07	3.00E-04	1.00E-05	3.33E-02	1.80E-06	6.00E-03
RM 5 East (UD)	Benzo(a)pyrene	4.60E+00	ug/kg	1.00E+00	5.10E-07	5.10E-07	9.30E-08	9.30E-08	3.00E-04	1.20E-06	4.00E-03	2.20E-07	7.33E-04
RM 5 West (UD)	Benzo(a)pyrene	4.60E+02	ug/kg	1.00E+00	5.10E-05	5.10E-05	9.30E-06	9.30E-06	3.00E-04	1.20E-04	4.00E-01	2.20E-05	7.33E-02
RM 6 East (UD)	Benzo(a)pyrene	3.80E+00	ug/kg	1.00E+00	4.20E-07	4.20E-07	7.70E-08	7.70E-08	3.00E-04	9.80E-07	3.27E-03	1.80E-07	6.00E-04
RM 6 West (UD)	Benzo(a)pyrene	4.90E+02	ug/kg	1.00E+00	5.40E-05	5.40E-05	9.90E-06	9.90E-06	3.00E-04	1.30E-04	4.33E-01	2.30E-05	7.67E-02
RM 7 East (UD)	Benzo(a)pyrene	2.40E+00	ug/kg	1.00E+00	2.60E-07	2.60E-07	4.80E-08	4.80E-08	3.00E-04	6.20E-07	2.07E-03	1.10E-07	3.67E-04
RM 7 West (UD)	Benzo(a)pyrene	1.90E+01	ug/kg	1.00E+00	2.10E-06	2.10E-06	3.80E-07	3.80E-07	3.00E-04	4.90E-06	1.63E-02	9.00E-07	3.00E-03
RM 8 East (UD)	Benzo(a)pyrene	1.40E+00	ug/kg	1.00E+00	1.50E-07	1.50E-07	2.80E-08	2.80E-08	3.00E-04	3.60E-07	1.20E-03	6.60E-08	2.20E-04
RM 8 West (UD)	Benzo(a)pyrene	5.00E+00	ug/kg	1.00E+00	5.50E-07	5.50E-07	1.00E-07	1.00E-07	3.00E-04	1.30E-06	4.33E-03	2.40E-07	8.00E-04
RM 8 SIL (UD)	Benzo(a)pyrene	3.90E+00	ug/kg	1.00E+00	4.30E-07	4.30E-07	7.90E-08	7.90E-08	3.00E-04	1.00E-06	3.33E-03	1.80E-07	6.00E-04
RM 9 East (UD)	Benzo(a)pyrene	1.80E+00	ug/kg	1.00E+00	2.00E-07	2.00E-07	3.60E-08	3.60E-08	3.00E-04	4.60E-07	1.53E-03	8.50E-08	2.83E-04
RM 9 West (UD)	Benzo(a)pyrene	1.90E+00	ug/kg	1.00E+00	2.10E-07	2.10E-07	3.80E-08	3.80E-08	3.00E-04	4.90E-07	1.63E-03	9.00E-08	3.00E-04
RM 10 West (UD)	NA	--	--	--	--	--	--	--	--	--	--	--	--
RM 11 East (UD)	NA	--	--	--	--	--	--	--	--	--	--	--	--
RM 11 West (UD)	Benzo(a)pyrene	3.20E-01	ug/kg	1.00E+00	3.50E-08	3.50E-08	6.50E-09	6.50E-09	3.00E-04	8.20E-08	2.73E-04	1.50E-08	5.00E-05
RM 12 East (UD)	NA	--	--	--	--	--	--	--	--	--	--	--	--
Study Area Wide (UD)	Benzo(a)pyrene	1.40E+02	ug/kg	1.00E+00	1.50E-05	1.50E-05	2.80E-06	2.80E-06	3.00E-04	3.50E-05	1.17E-01	6.50E-06	2.17E-02
RM 1 East (D)	Benzo(a)pyrene	4.30E-01	ug/kg	1.00E+00	4.70E-08	4.70E-08	8.70E-09	8.70E-09	3.00E-04	1.10E-07	3.67E-04	2.00E-08	6.67E-05
RM 2 West (D)	NA	--	--	--	--	--	--	--	--	--	--	--	--
RM 10 West (D)	NA	--	--	--	--	--	--	--	--	--	--	--	--
RM 11 East (D)	Benzo(a)pyrene	4.30E-01	ug/kg	1.00E+00	4.70E-08	3.00E-07	8.70E-09	8.70E-09	3.00E-04	1.10E-07	3.67E-04	2.00E-08	6.67E-05
RM 12 East (D)	Benzo(a)pyrene	3.10E-01	ug/kg	1.00E+00	3.40E-08	2.00E-07	6.30E-09	6.30E-09	3.00E-04	8.00E-08	2.67E-04	1.50E-08	5.00E-05
Study Area Wide (D)	Benzo(a)pyrene	4.30E-01	ug/kg	1.00E+00	4.70E-08	3.00E-07	8.70E-09	8.70E-09	3.00E-04	1.10E-07	3.67E-04	2.00E-08	6.67E-05
Minimum											2.67E-04		5.00E-05
Maximum											4.33E-01		7.67E-02
Location of Maximum:	RM 6 West (UD)												

Notes:

Cancer Risk was not estimated for the child recreational beach exposure scenario

For beach sediment and in-water sediment, only the exposure pathway with the lowest PRG was evaluated